



(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **94300839.1**

(51) Int. Cl.⁵: **C04B 7/24, C04B 7/43, F23G 7/00**

(22) Date of filing: **04.02.94**

(30) Priority: **26.02.93 DK 214/93**

(43) Date of publication of application:
07.09.94 Bulletin 94/36

(84) Designated Contracting States:
BE DE FR NL

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(54) **Method for manufacturing a pozzolanic material from paper sludge.**

(57) A method for manufacturing a pozzolanic material from paper sludge, e.g. derived from the manufacture of recycled paper, in a plant which comprises at least a drying and comminuting apparatus (1) and a kiln system (3). The paper sludge is introduced into a stream of hot exit gas from the kiln system (3) of the plant, conducted together with this gas to the drying and comminuting apparatus (1) and subsequently passed, suspended in the exit gas, to a separator (13). The separated, dry paper material is fed into the burning chamber (21) of the kiln system (3), and the organic matter of the material is incinerated with the development of heat, by means of which the mineral residue, primarily kaolin, is subjected to heat treatment. The heat-treated mineral material is eventually cooled in a cooler (25).

In this way the kaolinic, inorganic fraction of the paper sludge is transformed in an economic and environmentally acceptable manner into a material with pozzolanic properties, which can be utilized as an additive in the preparation of e.g. concrete, which will thereby obtain enhanced strength characteristics and increased density.

EP 0 613 867 A1

The present invention relates to a method for manufacturing a pozzolanic material from paper sludge, for example derived from the manufacture of recycled paper, in a plant comprising a drying and comminuting apparatus and a kiln system.

In this context, a pozzolanic material is taken to mean a material of oxides such as Al_2O_3 , Fe_2O_3 , SiO_2 or the like, which when incorporated into mortar or concrete may react with $Ca(OH)_2$ with the formation of minerals equivalent to those formed when ordinary cement minerals react with water. The two most important cement minerals $(CaO)_2SiO_2$ and $(CaO)_2SiO_2$ both react with water with formation of tobermorite-gel and $Ca(OH)_2$. When a pozzolanic material is incorporated into concrete, it is possible to reduce the consumption of cement quite substantially because of these factors, if attainment of the same strength characteristics is desired.

The manufacture of recycled paper based on the use of waste paper as the chief raw material generates large quantities of waste in the form of paper sludge. This paper sludge consists mainly of cellulosic fibres, printing ink, water and a mineral residue of paper fillers, and it is thought to be biodegradable. Nevertheless, the method of deposit which has been employed in the past, involving simple ploughing in of the paper sludge, is a matter of growing concern. Therefore, the emergence of paper sludge generated during the manufacture of recycled paper precludes utilization of the entire amount of recovered waste paper, which is undesirable, since from an ecological viewpoint it is preferable to manufacture paper from reclaimed material instead of from wood pulp.

Several methods have been proposed for utilizing paper sludge in the manufacture of cement in such a way that the cellulosic fibres and the printing ink are incinerated in the kiln system of the cement plant, whereas the mineral content is mixed into the cement clinker in the same manner as coal ash. In, for example, Japanese laid open patent application JP-A-56100222, a method is disclosed according to which the paper sludge is initially dehydrated by mechanical means, the produced sludge is subsequently dried and granulated, and the granulate is eventually used as a fuel in a cement kiln. In Danish laid open patent application No. 2829/90 filed on November 29, 1990, a method is suggested by which the paper sludge is mixed into the cement raw materials in a suspension which is subsequently passed to a rotary kiln operating according to the wet-process method. The suggested solutions in both patent applications have the disadvantage that the paper sludge, of which 50% is water and 25% is a burnable substance, have to be transported from the paper mill to the cement plant, which is disadvantageous in terms of cost efficiency. Further, the paper sludge is difficult to handle and is often malodorous.

Possibly, the most obvious method envisaged by

a specialist by which a pozzolanic material can be manufactured from paper sludge would be to carry out the process in a long rotary kiln, with firing being effected at one end, whereas the wet paper sludge is introduced at the other end, and subjected to drying and heating in counterflow with the kiln gases. The disadvantage of this solution is that malodorous gas compounds may be developed from the paper sludge already at the drying stage of the sludge or very early during the heat-up phase, which entails that these gases are discharged from the rotary kiln together with the exit gas without having been effectively destroyed. In addition to this environmental problem, the solution has the disadvantage that fuel, e.g. gas or oil, will be required for firing.

Another conceivable solution would be to utilize a traditional waste incineration plant provided with a grate. In such a plant it is possible to attain effective destruction of the generated gases and to reduce the usage of back-up fuel. However, this disadvantage of this solution is that it is difficult to achieve effective removal of the burnable carbon from the pozzolanic product, either because it is extremely difficult to maintain the fine-grained product on the grate for the sufficient length of time or due to the proneness of the material to form large lump formations in which the carbon is trapped.

It is the object of the present invention to provide a method for manufacturing a pozzolanic material from paper sludge by means of which the aforementioned disadvantages are remedied.

This is achieved according to the invention, in a plant comprising a drying and comminuting apparatus and a kiln system, by a method characterized in that the paper sludge is introduced into a stream of hot exit gas from the kiln system of the plant and is passed together with the gas to the drying and comminuting apparatus wherefrom dried and finely divided paper material is passed suspended in the exit gas to a separator in which the paper material is separated from the exit gas; in that the separated, dry paper material is fed into a burning chamber of the kiln system where the organic matter of the material is incinerated with the development of heat, by means of which the mineral residue is subjected to heat treatment for an appropriate period of time and at a controlled temperature; and in that the heat-treated mineral material is eventually cooled in a cooler.

It is thus obtained that the primarily kaolinic, inorganic fraction of the paper sludge is transformed into a material with pozzolanic properties, which can be used as an additive for preparation of e.g. concrete, which will thereby obtain enhanced strength characteristics and increased density. The fact that burnt clays, including heat-treated kaolin, possesses pozzolanic properties has been recognized and utilized from antiquity (see e.g. Lea & Desch: The Chemistry of Cement and Concrete, Edward Arnold & Co.,

London, 1935, p. 249). Since the plant to be used according to the invention can be sited near the paper mill from which the paper sludge is derived, this may further eliminate the need for a potentially long and expensive transportation of the paper sludge to a cement plant. The pozzolanic material manufactured by the method according to the invention has a weight which is only about 25% that of the paper sludge, and, therefore, it can be transported directly to a concrete factory or a building site in a less expensive manner.

The manufacturing process according to the invention is furthermore CO₂-neutral in itself since the amount of CO₂ which is formed during the incineration of the organic matter of the paper sludge is equivalent to the amount which would be formed by biological degradation in connection with ploughing in. It is further obtained that the CO₂-emission resulting from the use of concrete is reduced since the total amount of cement which is to be burned per tonne of finished concrete is reduced when the pozzolanic material is utilized as an additive in the concrete.

Finally, it is obtained that a greater amount of waste paper than hitherto can be utilized for the manufacture of new paper, without any attendant deposit problems.

The dry paper material which is separated from the exit gas in the separator can be fed directly into the burning chamber of the kiln system, but in order to obtain an effective and controlled firing it is preferred that the paper material from the separator is initially passed to a storage vessel, from which it is subsequently extracted and fed into the burning chamber of the kiln system.

In one example of the method according to the invention the paper material is fed via a burner installation into a rotary kiln for formation of a flame herein, whereby the organic matter of the material is incinerated with the development of heat and the mineral residue is precipitated in the rotary kiln, whereas the exit gas produced during the incineration is passed to a dust separator in which mineral dust is separated and returned to the rotary kiln, and the returned dust together with the remaining mineral material in the rotary kiln is, by virtue of the rotation of the kiln, led along below the flame and thereby subjected to heat treatment under controlled conditions, the heat-treated mineral material being subsequently conducted to the cooler.

In a second example of the method according to the invention the paper material is fed into a calciner via a burner which is situated close to a bottom inlet of the calciner up through which combustion air is supplied, whereby the organic matter of the material is incinerated subject to development of heat, and the mineral residue is subjected to heat treatment, whereafter the heat-treated mineral material suspended in the combustion gas is passed to a separator in which it is separated from the gas and conducted

to the cooler.

The mineral, heat-treated material can be cooled by means of cooling air which is subsequently utilized as combustion air in the kiln system.

The exit gas utilized for drying may be malodorous and may contain various harmful organic elements, and, therefore, it may be recirculated via a fan to the kiln system of the plant in which, together with fresh air, it is first passed through the cooler in order to cool the material and then passed through the burning chamber, whereby the unwanted substances in the exit gas are destroyed.

There will be a constant need for supplying the plant with fresh air from external sources, and since, during normal operation, the plant will be heat-producing, a partial stream of the hot exit gas from the kiln system is extracted at a rate which is equivalent to the input of fresh air and conducted to a plant for waste heat utilization.

The extracted exit gas may subsequently be cleaned in a precipitator installation from which the dust is returned to the kiln system, while the cleaned exit gas is vented into the atmosphere via a fan.

The invention also includes apparatus for carrying out the new method the apparatus comprising a kiln system; and means for introducing paper sludge into a hot exit gas duct from the kiln system, the duct leading to a drying and comminuting apparatus and hence to a separator, a material outlet from the separator leading to a burning chamber of the kiln system, and a material outlet of the kiln system being connected to a cooler.

The invention will now be described in further detail with reference to the accompanying diagrammatic drawings, in which:

Fig. 1 shows a first plant for carrying out the method according to the invention, and

Fig. 2 shows a second plant for carrying out the method according to the invention.

The plants shown in Fig. 1 and 2 both comprise a drying and comminuting apparatus in the form of a drier crusher 1 which through a duct 5 is supplied partly with hot exit gas from a kiln system 3 and partly a paper sludge, substantially dehydrated paper sludge, from a store 7. The dry and finely divided paper material is carried via a duct 9 and by means of a fan 11 suspended in the exit gas to a separation cyclone 13 in which the paper material is separated from the exit gas and directed to a storage vessel 15. The paper material is extracted from the storage vessel 15, possibly by means of a screw conveyor and is fired into the kiln system 3 of the plant via a burner 17.

In addition to the burner 17, the kiln system 3 of the plant shown in Fig. 1 comprises a rotary kiln 21, a dust cyclone 23 and a planetary cooler 25. The paper material is fired via the burner 17 into the rotary kiln 21 in such a way that a flame is formed herein.

As a result, the organic matter of the material is incinerated with the development of heat, and a part of the mineral residue is precipitated in the kiln. The exit gas produced during incineration is conducted to the dust cyclone 23, in which the remaining amount of mineral dust is separated and returned to the rotary kiln 21. In the rotary kiln 21 the mineral material, by virtue of the rotation of the kiln and its inclination, is led backwards (i.e. in the direction opposite to that in which the flame is directed) below the flame, thus being subjected to heat treatment under controlled conditions, e.g. so that a maximum temperature of the material in the range 700 - 850°C is achieved. From the rotary kiln the heat-treated mineral material is conducted to the cooler 25 in which it is cooled in counterflow with the exit gas from the separation cyclone 13 which is supplied to the cooler 25 via a duct 27 and the fan 11. The product which is often nodulized into smaller and larger balls as a consequence of the motions in the rotary kiln must subsequently be subjected to some form of grinding in a grinding mill (not shown) prior to its final application.

In addition to the burner 17, the kiln system 3 of the plant shown in Fig. 2 comprises a calciner 31, a dust cyclone 33 and a cyclone cooler 35. The paper material is fired into the calciner 31 via the burner 17 which is situated near its bottom inlet 32 up through which hot combustion air is supplied from the cyclone preheater 35. As a result, the organic matter of the material is incinerated with the development of heat, by means of which the mineral residue is subjected to a heat treatment. The heat-treated mineral material is conducted suspended in the combustion gas to the dust cyclone 33 in which it is separated from the gas and directed to the cooler 35 in which it is cooled in counterflow with the exit gas from the separation cyclone 13, which is supplied to the cooler 35 via a duct 37 and the fan 11. In this type of plant the product is not allowed to nodulize, which is advantageous since this will eliminate the need for subsequent grinding. However, processing of the product must take place at a higher temperature, so that any CaCO_3 content in the material is decomposed into CaO and CO_2 . Presence of the free CaO in the product will be acceptable if it quickly reacts to Ca(OH)_2 on contact with water. Since, in the vast majority of cases, slaking of lime burned in a calciner will quickly occur, as shown by experience, thereby avoiding the problems in terms of expansion damage in concrete otherwise encountered when the cement contains free CaO .

As it appears from both figures, the exit gas from the drier crusher 1 is recirculated by means of the fan 11 and substantially by means of fresh air supplied via a fresh-air intake 10 to the kiln system 3. In the kiln system 3 the recirculated exit gas is heated to a temperature of between 800 and 1000°C, which is sufficient to destroy any obnoxious and/or harmful substances.

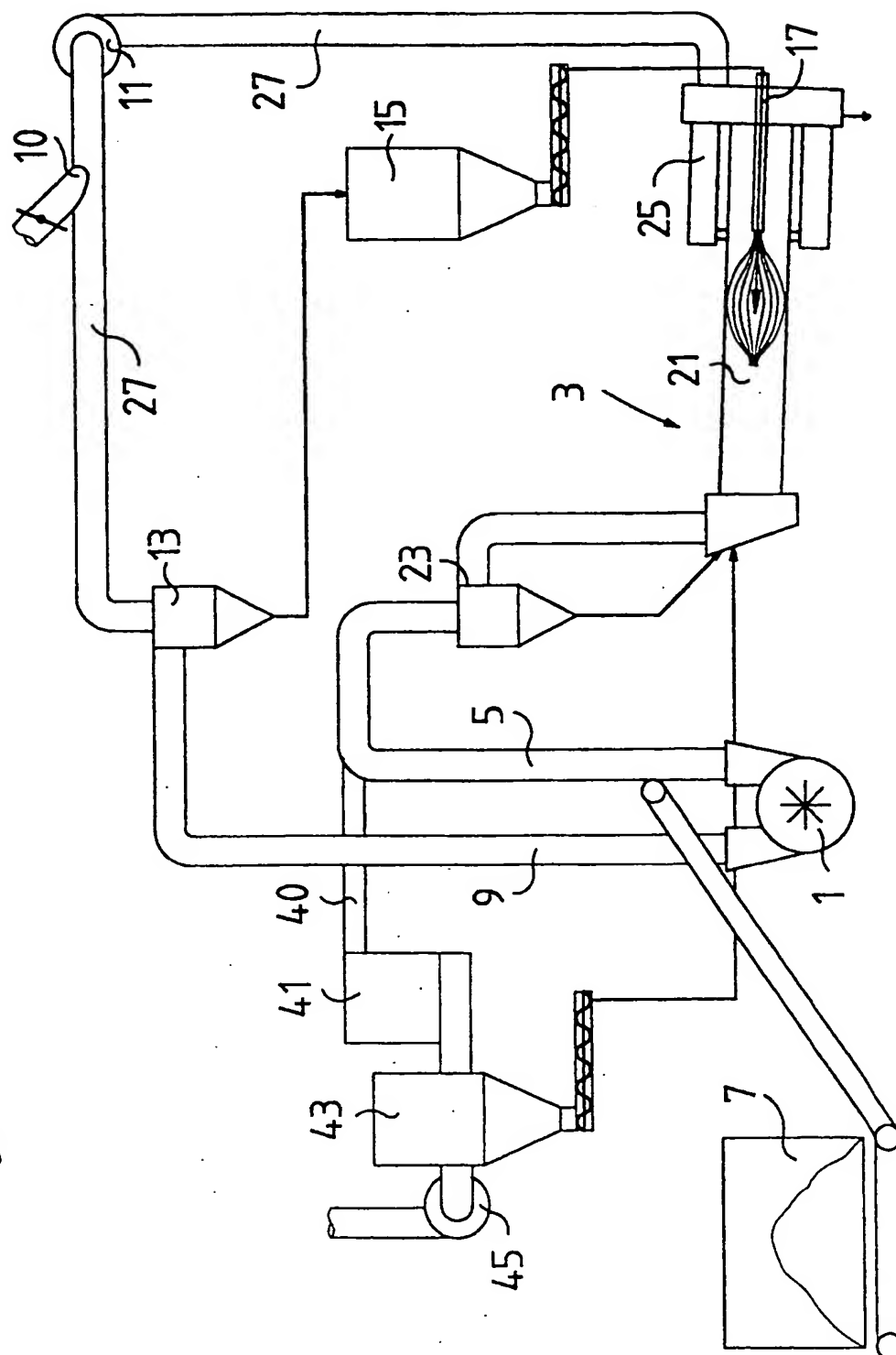
Since, as previously mentioned, the plant will be heat-producing during normal operation, a partial stream 40 of the hot exit gas from the kiln system 3 may be extracted at a rate which is equivalent to the input of fresh air and is conducted to a plant 41 for waste heat utilization. Such a plant 41 may be designed for the production of steam or district heating water. From the plant 41 the now cooled exit gas is passed to a filter 43, such as a bag filter or an electrostatic precipitator, subsequently being vented to the atmosphere via a fan 45.

Claims

1. A method for manufacturing a pozzolanic material from paper sludge in a plant comprising a drying and comminuting apparatus (1) and a kiln system (3), characterized in that the paper sludge is introduced into a stream of hot exit gas from the kiln system (3) of the plant and is passed together with the gas to the drying and comminuting apparatus (1) wherefrom dried and finely divided paper material is passed suspended in the exit gas to a separator (13) in which the paper material is separated from the exit gas; in that the separated, dry paper material is fed into a burning chamber (21, 31) of the kiln system (3) where the organic matter of the material is incinerated with the development of heat, by means of which the mineral residue is subjected to heat treatment for an appropriate period of time and at a controlled temperature; and in that the heat-treated mineral material is eventually cooled in a cooler (25, 35).
2. A method according to claim 1, wherein the dry paper material is conducted from the separator (13) to a storage vessel (15) from which it is extracted and fed into the burning chamber (21, 31) of the kiln system (3).
3. A method according to claim 1 or claim 2, wherein the dry paper material is fed via a burner installation (17) into a rotary kiln (21) forming the burning chamber of the kiln system where the organic matter of the material is incinerated to produce a flame; the mineral residue is precipitated in the rotary kiln (21); the exit gas produced during the incineration is passed to a dust separator (23) in which mineral dust is separated and returned to the rotary kiln (21), and the returned dust together with remaining mineral material in the rotary kiln is, by virtue of the rotation of the kiln, led along below the flame and thereby subjected to heat treatment under controlled conditions, the heat-treated mineral material being subsequently passed from the rotary kiln (21) to the cooler (25).

4. A method according to claim 1 or claim 2, wherein the dry paper material is fed into a calciner (31), forming the burning chamber of the kiln system, via a burner which is situated close to a bottom inlet (32) of the calciner up through which combustion air is supplied; the organic matter of the material being incinerated in the calciner with the development of heat, thereby subjecting the mineral residue to heat treatment; and the heat-treated mineral material suspended in the combustion gas is passed to a separator (33) in which it is separated from the gas and conducted to the cooler (35). 5 10
5. A method according to and one of the preceding claims, wherein the heat-treated mineral material is cooled by means of cooling air which is subsequently utilized as combustion air in the kiln system (3). 15 20
6. A method according to any one of the preceding claims, wherein the exit gas utilized for drying is recirculated via a fan (11) to the kiln system (3) of the plant in which, together with fresh air, it is first passed through the cooler (25, 35) in order to cool the material and then passed through the burning chamber (21, 31), whereby the unwanted substances in the exit gas are destroyed. 25 30
7. A method according to any one of the preceding claims, wherein a partial stream (40) of the hot exit gas from the kiln system (3) is extracted at a rate which is equivalent to an input of fresh air and conducted to a plant (41) for waste heat utilization. 35 40
8. A method according to claim 7, wherein the extracted exit gas is subsequently cleaned in a precipitator installation (43); and the dust from the precipitator (43) is returned to the kiln system (3), whereas the cleaned exit gas is vented to the atmosphere via a fan (45). 45 50
9. Apparatus for carrying out a method according to any one of the preceding claims, the apparatus comprising a kiln system (3); and means (7) for introducing paper sludge into a hot exit gas duct (5) from the kiln system (3), the duct leading to a drying and comminuting apparatus (1) and hence to a separator (13), a material outlet from the separator leading to a burning chamber (21, 31) of the kiln system (3), and a material outlet of the kiln system being connected to a cooler (25, 35). 55 5

Fig. 1



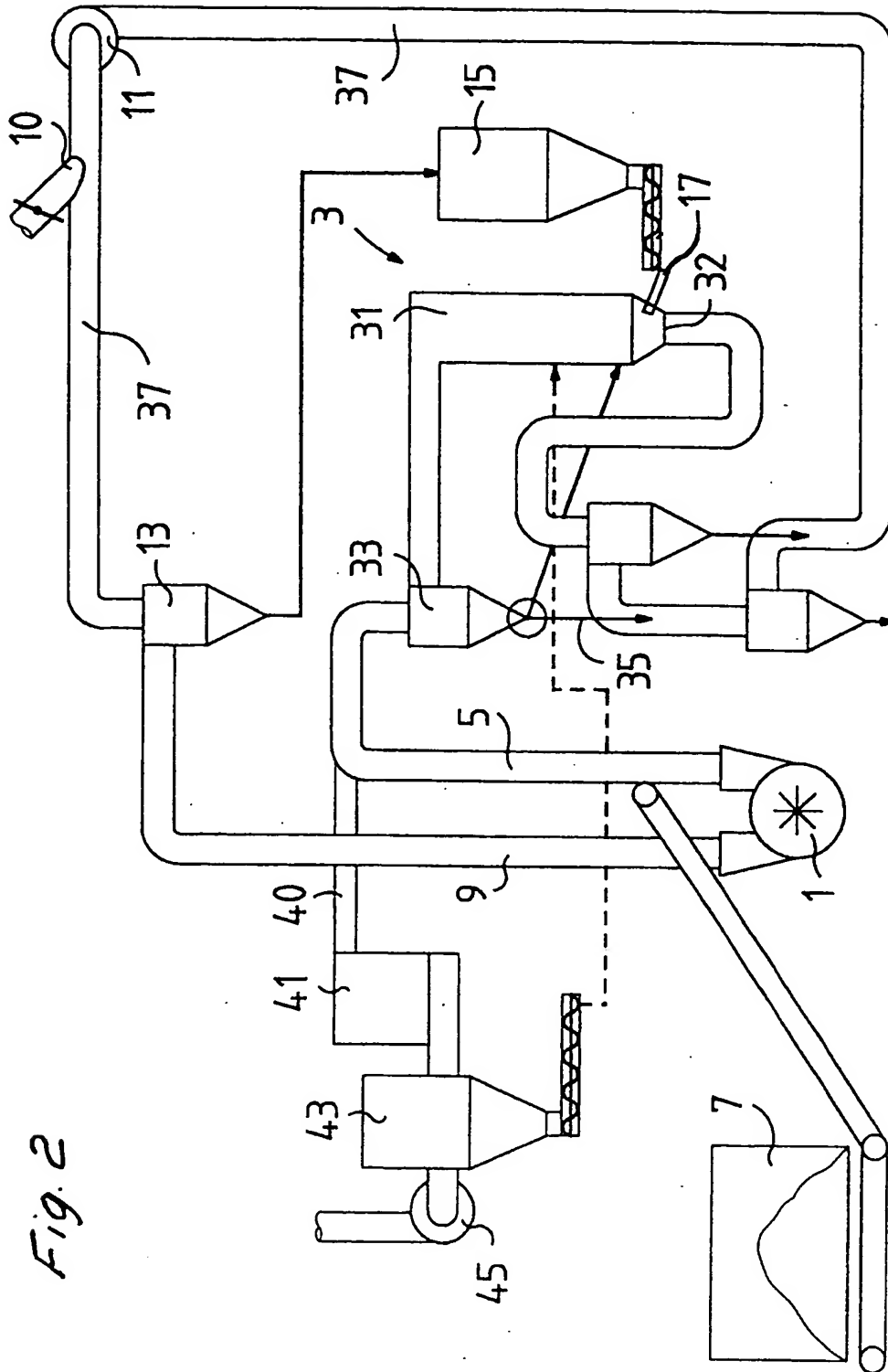


Fig. 2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 0839

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	GB-A-173 504 (E. BOUCHAUD-PRACEIQ) * page 1, line 37 - line 46; claim 1 *	1	C04B7/24 C04B7/43 F23G7/00
Y	EP-A-0 488 989 (WOPFINGER STEIN- UND KALKWERKE SCHMID & CO) * Abstract *	1	
A	RESEARCH DISCLOSURE no. 345 , January 1993 , HAVANT GB pages 59 - 60 XP336546 'Plant for processing of waste for firing into a kiln system'	1	
A	US-A-3 858 535 (K. SHIBA) * Abstract, line 1-4 *	1	
A	DE-A-35 23 677 (KLÖCKNER-HUMBOLDT-DEUTZ AG) * Abstract *	1,7	
A	FR-A-1 362 956 (VON ROLL A.G.)		TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			C04B F23G
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 6 June 1994	Examiner Daeleman, P
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